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Regulatory Communication and
Knowledge Base System

Development of the Regulatory Communication and Knowledge Base System and Investigation of Possible Augmentation Technologies

by
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The process of evaluating and granting permits for dredge and fill materials in navigable waters of the United States is becoming more complex each year. In addition, valuable information and experience are lost when employees leave or retire. The U.S. Army Construction Engineering Research Laboratory (USA-CERL) has investigated potential computer-based methods for addressing these issues for the Regulatory Branch, Operations and Readiness Division, Directorate of Civil Works, Headquarters, U.S. Army Corps of Engineers (CECW-OR).

This report discusses the development of an electronic mail and bulletin board system for the Regulatory Branch. It also assesses the feasibility of supplementing this system with more computing power, in the form of an expert system, and more storage, in the form of video data retrieval technology. The bulletin board system is already in place and is being used. Both expansion options were found to be desirable and feasible, and a prototype expert system was developed. Appendices document the features used to select an expert system shell and the development of the prototype expert system. USA-CERL ADP Report N-88/11, *User Manual for the Regulatory Communication and Knowledge Base System*, provides instructions for the bulletin board and electronic mail system.

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FOREWORD

This investigation was conducted for the Directorate of Civil Works, Headquarters, U.S. Army Corps of Engineers (HQUSACE), under Research and Development Work Unit 32294 in the Construction, Operations, and Maintenance Program. The original title of this work unit was "Permit Monitoring Program." In FY87, at the request of the Technical Monitor, the title was changed to "Regulatory Communication and Knowledge Base System." The HQUSACE Technical Monitor was Mr. Jack Chowning, CECW-OR.

The work was done by the Environmental (EN) Division of the U.S. Army Construction Engineering Research Laboratory (USA-CERL). Dr. R. K. Jain is the Chief of USA-CERL-EN. Mr. John Fittipaldi was the Principal Investigator. Members of the University of Illinois Department of Urban and Regional Planning, specifically Ms. Deanna Glosser, Mr. Clint Erb. and Dr. Lewis Osborne, provided contractual contributions to many phases of this project. The technical editor was Ms. Jane Andrew, Information Management Office.

COL Norman C. Hintz is the Commander and Director of USA-CERL, and Dr. L. R. Shaffer is the Technical Director.

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DEVELOPMENT OF THE REGULATORY COMMUNICATION AND KNOWLEDGE BASE SYSTEM AND INVESTIGATION OF POSSIBLE AUGMENTATION TECHNOLOGIES

1 INTRODUCTION

Background

Administration of permit applications for dredge and fill materials in navigable waters of the United States* has been a challenge to regulators for many years. U.S. Army Corps of Engineers staffs are under pressure to accomplish more work with fewer resources. It has also been difficult to obtain the optimum mix of technical expertise within district offices to properly process the applications and to conduct surveillance and enforcement. Regulatory personnel possessing unique expertise and experience often leave or retire without passing on their knowledge.

Current and emerging computer software and hardware could be used to foster a base of shared expert knowledge on reulatory operations management. These are some of the expected advantages:

- Retention of knowledge in an area of expertise
- Expansion of this corporate knowledge as experience and expertise develops
- Easy access to the latest ideas, knowledge, and expertise, independent of geographical or organizational proximity
- Easier pooling of experiences, problem sharing, and problem solving.

Objectives

This project had three major objectives:

1. Establish a computer-aided network (electronic mail and bulletin board) to enhance communication among Corps field personnel engaged in the regulatory program. This network should provide a framework for storing institutional knowledge and experience normally lost when employees retire or resign.

2. Investigate the feasibility of developing an expert system decision-making software package for use in the regulatory program that would facilitate consistent, high-quality, regulatory decision-making.

3. Investigate the use of video data storage technology to supplement the expert system software.

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*Permits regulated primarily under Section 10, Rivers and Harbors Act of 1899 (33 U.S.C. 403) and Section 404, Federal Water Pollution Control Act of 1972 (PL 92-500).

Approach

- For electronic mail and bulletin board system (Kbase):
  - -- Select computer service.
  - -- Develop and document Kbase.
  - -- Provide training on system and encourage its use.
  - -- Recommend a long term technology transfer strategy to provide for maintenance and development.

- For expert system:
  - -- Investigate commercial expert system shells and select the one most suitable for supporting a system for the Regulatory Branch.
  - -- Develop a prototype system using the recommended shell.

- For video data storage:
  - -- Review current and newly developed technologies and assess their potential usefulness in regulatory applications.

Mode of Technology Transfer

Continuing support of the Regulatory Communication and Knowledge Base System will be provided through the sponsoring office: the Regulatory Branch of the Operations and Readiness Division, Directorate of Civil Works (CECW-OR). A system manager will be responsible for daily maintenance, promotion, and training. CECW-OR is scheduled to take over responsibility for the system in May 1988. USA-CERL has conducted workshops for regulators and distributed newsletters about the system.

2 ELECTRONIC MAIL AND KBASE BULLETIN BOARD

The administration of the Corps regulatory program has become increasingly complex because more permit applications are being received, requiring more personnel to process them, and because more agencies have become involved in the decision-making process. A computer-aided network, consisting primarily of electronic mail, was seen as a means of enhancing communication between Corps offices, as well as between Corps offices and the Federal agencies involved. In other situations, such networks have facilitated the timely and efficient exchange of information among these many agencies.

A need was also identified within the Corps for storing and retrieving the institutional knowledge which is normally lost when employees retire or resign. An electronic bulletin board was proposed as an appropriate mechanism to store such knowledge and experience and to make it available to all Corps regulatory personnel.

An electronic bulletin would provide three major benefits for the regulatory process:

1. A facility for storing all knowledge regarding an area of expertise
2. The ability to expand as an area of expertise grows and changes
3. Remote access to the latest ideas, knowledge, and expertise.

To develop a usable bulletin board, a dial-up computer service was selected first. Next the specific needs of the regulators were identified through site visits and questionnaires. A bulletin board was then designed, and examples of appropriate information were entered for demonstration purposes.

The bulletin board system was actively promoted by the system manager, who sent introductory letters through electronic mail, distributed instructional materials, and located and entered information of value to regulatory personnel. In the final stage of the project the long-term operation and maintenance requirements were assessed and customized user documentation was developed.

Computer Network

The Regulatory Branch was already using the electronic mail services of Dialcom, Inc., a firm based in Washington, DC. Another computer service could have been selected for the bulletin board, but Dialcom was found to be satisfactory for several reasons:

- The Regulatory Branch's previous selection of Dialcom provided financial and conceptual support for the project.
- Because regulatory personnel were already using Dialcom's electronic mail, a user group existed for the bulletin board. Users would therefore presumably be familiar with the operation of the system, requiring less training.
- Dialcom is user friendly, with concise and understandable documentation.
- Dialcom offered a wide variety of services that could be incorporated into a complete package.

- Dialcom also provided a representative assigned to the account to answer questions and assist in system operation. Any problems that occur would be directed to this representative, providing continuous support.

Dialcom Services

A variety of services are available from Dialcom, among them data transfer packages, a text editor, a news wire service, an official airline guide, and Tradepost (a bulletin board service). A package of services was arranged and made available to regulatory personnel in October 1986 in the form of a menu-driven system entitled the "Regulatory Communication and Knowledge Base System" (Table 1).

Bulletin Board

Kbase, the bulletin board developed for this system, stores the institutional knowledge which is normally lost when employees retire or resign. Kbase can contain up to 125 separate categories. Information is posted in each category, and is numbered sequentially as it is entered. To design Kbase, a list of acceptable categories was developed by contacting key regulators. These were entered, along with an introductory paragraph for each that describes the information suitable for each category. The bulletin board began with six categories but has since been expanded to 17 (Table 2). A variety of methods were used to tell the users Kbase and other services were available. Messages were sent to all users of the existing electronic mail explaining the new features. A manual was also prepared and distributed, which explained the entire system and provided instructions for the major services, such as electronic mail, Kbase, Official Airline Guide (OAG), text editor, and the spelling checker.[1]

Table 1

Menu of Services Available in the Regulatory Communication and Knowledge Base System

KBASE	Bulletin Board System
MAIL	Electronic Mail
WPMAIL	Uploading files from your PC or Word Processor
OAG	Official Airline Guide
XMIT	Transfer Files between PC/word processor and Dialcom
LEARN	Self-instructional training program on mail
FEDNEWS	Newsletter service provided by government agencies
BOXES	Mailbox directories for various government agencies
COMMENTS	Users comments form for the system's operation
SYSTEM	Command level for advanced users
OFF	Signing off the system

[1] Deanna Glosser and John Fittipaldi, *User Manual for the Regulatory Communication and Knowledge Base System*, ADP Report N-88/11 (USA-CERL, July 1988).

Table 2

Categories Currently in Kbase

AA Open Forum	AB Wetlands
AC Public Participation	AD Meetings
AE General Permits	AF News Articles
AG Job Openings	AH Streams
AI Decision Documents	AJ Dialcom Tips
AK Training	AL Program Info
AM OCE	AN Mitigation
AO NED	AP NCD
AQ Environment Reporter	

Corps personnel can receive a login to use the bulletin board by requesting one from the system manager.* Non-Corps users must be approved by HQUSACE (CECW-OR). There are roughly 110 Dialcom IDs currently issued to Corps personnel nationwide. About 56 logins access the system three or more times a week.

Problems and Solutions

It became soon apparent that users were reluctant to access Kbase and contribute information. To overcome this reluctance, the system manager located and entered usable information. One source of information was the news wire service available through Dialcom. A key word index was created, allowing all news articles on specific topics to be forwarded to the system manager's mailbox. Appropriate articles were then entered into a Kbase category. Other sources of information were sought. An arrangement was made with the Environmental Information Connection (EIC), a data base search service, to locate information on the subjects that appear in Kbase. If a user placed a question in the bulletin board, the EIC director would run a search and upload the items found pertaining to the specific question. This arrangement has great potential, but it has been limited by the speed with which these searches can be run and by the small number of questions placed in Kbase by users.

A second problem was that only one Dialcom identification number (ID) was assigned to each Corps district and division office. Several users expressed a reluctance to use the same ID as their superiors. Additional IDs were made available to those offices that expressed an interest. Additional IDs were also created for field offices. The latter solution has been quite successful in increasing communication between field and district offices, but has had little impact on the contributions made to Kbase.

Some regulators also expressed concern that contributing to Kbase may be construed by other Federal agencies or the courts as policy-making. This issue was discussed at length with the project sponsor. It was made clear that Dialcom messages,

*To get a login, call (217) 333-1369.

particularly the contributions to Kbase, were informal and not binding. A letter encouraging support of the system and explaining the policy issue was released by Chief of the Regulatory Branch, HQUSACE.

Some obstacles to the widespread use of Kbase have been encountered, and they are difficult to resolve in a research and development project. For example, many offices lack the appropriate computer equipment or telephone lines for modems to access Dialcom. In many cases, there is only one computer terminal or one dedicated phone line in the office that can be used for accessing Dialcom. This inhibits the frequent use of Kbase or other services. Second, regulatory decision-makers are sometimes skeptical of the value of computers in the office and therefore do not whole-heartedly encourage their use. In other instances, the computer is viewed as the domain of the secretarial staff, which limits who has access to the system. Finally, most regulators have had little experience with computers or the Dialcom system. They use the system on a very basic level, which limits their ability to contribute information. In other cases, they have used computers but have no knowledge of Dialcom. In these cases, assistance from the system manager markedly increased users' contribution to the system.

Of these obstacles, the lack of computer experience is the easiest to overcome. Instructional materials were developed for Dialcom and for Kbase in particular. The system manager met with several district offices, providing instructions to interested staff. Following each small workshop, use of the system increased, although contributions to Kbase did not. This might be because most of the workshop was spent on upgrading Dialcom skills rather than focusing on how Kbase might be used most effectively. In another approach, training sessions could be developed to be included in the Regulatory I through IV courses sponsored by HQUSACE. These instructional materials should also become a part of the course manuals. These materials could also be included in the *Regulatory Handbook*, which is provided to each regulator. In this way, the instructions for operating Dialcom would be in a centralized location. This would also encourage the use of Dialcom's services when processing permits. Finally, more instructional workshops could be presented to districts. These workshops would only need to be offered until most of the current staff have attended one. Later, new employees could learn from other staff and from the manuals.

Long Term Operation and Maintenance

Three issues must be considered to ensure efficient future operation of the Kbase bulletin board system. These are system maintenance, information maintenance, and promotion and instruction.

Dialcom is completely responsible for maintaining the hardware and software which support the bulletin board and for addressing any changes or problems in that system. However, Dialcom representatives cannot be expected to assume responsibility for the information on the bulletin board. Someone familiar with regulatory administration must periodically delete obsolete messages. Someone must also run a disk compaction program (this does not require regulatory expertise). Finally, Dialcom representatives can conduct workshops, but they would only cover Dialcom services. Instruction on using the bulletin board information most effectively must come from persons with experience in regulation.

Thus, successful maintenance of the system depends on the involvement of persons outside Dialcom. Ideally, a system manager would be assigned the responsibility for daily maintenance and long-term promotion. His or her activities would include:

- Accessing the system daily, cleaning up the bulletin board and notifying Dialcom of any communications problems
- Addressing specific user problems
- Finding or soliciting new material and uploading it into Kbase
- Coordinating instruction and promotion efforts.

A more comprehensive approach to system promotion might be employed, as the Environmental Protection Agency (EPA), which also uses Dialcom services, has done. In addition to having a system manager, this agency has identified "electronic mail coordinators" within each region to encourage use of the services and serve as the primary contact person for Dialcom within that region. This concept could be implemented for the present system, with the responsibility of each coordinator being expanded to include the contribution of materials to Kbase.

3 EXPERT SYSTEM DEVELOPMENT FEASIBILITY

In the second phase of the project, the researchers examined the feasibility of incorporating the Federal regulations of the Regulatory Branch into a knowledge-based expert system. Such a system would be designed to bring consistency to the Corps' permit application process. It could be distributed to district and field offices throughout the nation, where it could make the decision-making process much more efficient in terms of time and manpower.

First, general data on expert system software was collected and analyzed. Four corporations that offered expert system development shells appropriate for the Regulatory Branch's needs were then selected, and their products were reviewed in greater detail. As a result of the evaluation, the systems offered by two of these four were further critiqued by means of demo disks or corporate demonstrations. Following these demonstrations and after a final review of the systems with Corps representatives, a final system was recommended for development and implementation.

Description of an Expert System

An expert system is a computer program that emulates the problem solving skills of an expert. It allows "nonexperts" to use knowledge and reasoning abilities that usually require an expert individual. The term artificial intelligence (AI) is used in explaining how expert systems analyze narrow and clearly defined problems.

> "Expert systems capture knowledge or data in a field and use this knowledge to make decisions and choices at a user's request. Overall, expert systems accept human knowledge, process it, draw conclusions and arrive at answers a human expert would give when asked to respond to the same questions."[2]

A complete expert system consists of three parts: a human-machine interface, an inference engine, and a knowledge base. The human-machine interface links the user and the inference engine. This has also been referred to as the work space. It accepts the user's input, and forwards it to the inference engine. Once the process is complete, it displays the results in either textual or graphic form.[3] The inference engine, on the other hand, is the actual worker or "thinking brain" behind the expert system. It accepts the input from the human machine interface, searches the knowledge base for facts, and from the two, draws conclusions based on those facts. Finally, the knowledge base contains all the factual information. It is, in essence, the memory of the system which must be supplied by the human expert.

When an expert system is first used, it consists of the human interface, the inference engine and an empty knowledge base. The system, in this form, is termed the shell. The shell, or more specifically, the knowledge base, is filled with the knowledge from a human expert. This system only becomes an expert system when the knowledge base, the expertise on a particular subject, is added.

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[2] William Hawkins, "Expert Systems Promise Supersmart PCs," *Popular Science*, March 1986, p 83.

[3] William Hawkins, p 83.

Two types of expert system are available: rule-based and non-rule-based (example-based). Rule-based systems organize facts (data) by having the developer write explicit rules. For example, "if 'A' and 'B' then 'C'." After rules in this form are developed, using the system involves answering a series of questions the program asks in an attempt to reach a decision.

A non-rule-based or example-based system is appropriate for situations in which data is in the form of data samples, such as data bases or spreadsheets. To develop an example-based system, the knowledge engineer defines the possible results and the factors that will determine the result by simply listing them, then gives some examples of decisions or outcomes that are typical for the situation. Finally the engineer tells the system to develop a rule given the previous information. In effect, the system takes the engineer's input and develops its own rules. The rule takes the form of a decision tree that can be useful in and of itself, or the engineers can create an advisor system by attaching text to the various nodes of the tree.

After rules have been developed, most expert systems are designed to read through each rule, eliminating those not applicable to the solution, while retaining the rules that are. This step-through process is called chaining, and two methods are used. Forward chaining is used to arrive at a conclusion based on facts supplied by the end users. Backward chaining is used to derive the facts from a known conclusion.[4]

Uses and Advantages of an Expert System

Currently there are numerous expert systems online throughout the world. The following is a brief list of current and planned applications of expert systems.[5]

- Medical diagnosis
- Computer configuration
- Equipment failure diagnosis
- Chemical data interpretation/structure elucidation
- Experiment planning
- Speech and image understanding
- Financial decision making
- Electronic signal interpretation
- Mineral exploration
- Military intelligence and planning

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[4] William Hawkins, p 83.

[5] "An Expert System Development Tool" (Software Architecture and Engineering [A&E], Inc., 1986).

- Advising about computer system use
- Integrated circuit design.

Although this is only a portion of all online expert systems, it is obvious that expert systems are being applied in many professional fields and institutions. More specifically, there are six major expert systems that are online and considered the front runners in development in the field.

Stanford's DENDRAL determines molecular structure from mass spectrometer data. Stanford also has MYCIN, which is used primarily to diagnose bacterial blood disease. Stanford Research Institute's PROSPECTOR has begun to be used as an advisor for mineral exploration and has proven successful in locating many ore deposits previously missed by other methods of exploration. Schlumberger Corporation's DIPMETER gives advice on the best locations for oil drill sites. Finally, Westinghouse has produced STEAMER, which trains machinist mates in shipboard repair and maintenance.[6] The Texas Instruments' expert system applications manual for their Consultant software series contains a complete listing of expert systems currently in use or under development.[7]

The aforementioned systems were developed on larger, more powerful mainframe systems, such as VAXes. For the last 30 years these were the primary development tools for expert system technology. In the past, only room-sized mainframe computers and, more recently, expensive minicomputers could handle the programming needed to mimic an expert. However, the speed and power of the personal computer has increased at a phenomenal rate. Currently, expert system programs are available and continue to be developed for the IBM personal computers and compatibles. Many of the front-running expert systems mentioned earlier have been downscaled to PC applications and can now be operated in field situations and in the smallest of research centers.

Expert systems technology is being developed so aggressively on the PC primarily because of its promise of advantages over standard computer programs of today. Software Architecture and Engineering, Inc. (Software A&E) has prepared the following listing of five major features which distinguish expert system technology from standard computer programs:[8]

1. Expert systems make expertise immediately available in any particular interest region (e.g., field work in mineral exploration).

2. Expert systems eliminate individual biases, prejudices, and errors due to a human expert's oversight or fatigue.

3. Expert systems are valuable teaching aids because they can justify their conclusions; standard programs lack this feature.

4. Expert systems capture valuable corporate knowledge.

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[6]"An Expert System Development Tool," 1986.
[7]"Expert Systems Applications Developed Using the Consultant Series," (Texas Instruments, 1986).
[8]"An Expert System Development Tool," 1986.

5. Expert systems free up experts' valuable time and allow them to spend more time researching and developing in their particular field of expertise.

Selecting a System Production Language for Easy Prototyping and End Use

When expert system technology first emerged from the academic arena, systems were written in either LISP (LISt Processing language) or Prologue. However, because of the complexity of developing a system in these languages, LISP and Prologue are not going to carry expert systems into the commercial setting. Many feel that LISP-based systems are too large for most commercial applications.[9] In general, however, LISP and Prologue systems are far too complicated and require far too much technical training and expense. Both languages are available on personal computers and have been researched in this study. However, to fulfill the Corps' immediate requirements and limitations, complex processing languages such as LISP and Prologue are not needed in the proposed applications.

Recent developments have solved many of the complications accompanying LISP and Prologue systems. According to Software A&E, systems can now be written in "C," a language which simplifies the development process and makes it available to nonexperts in the field. Not only are applications in "C" simpler to develop, they can also be embedded in other, non-expert-system programs which are largely written in "C." Being able to pass data efficiently in and out of an expert system opens a wide array of applications which are unavailable in LISP or Prologue. Expert systems written in "C" run much faster and more efficiently than ones in LISP or Prologue. This is helpful in situations requiring cost and time efficiency. Because "C" is such a versatile language, a much wider variety of personal computers will be able to run the program; however, a complete list of these is not available.

Problems/Limitations Related to the Regulatory Project

There are several potential limitations to the integration of expert systems into the Corps regulatory program:

- Difficulty in selecting applicable Federal regulations
- Difficulty in keeping up with changing regulations
- Possibly lengthy testing and refinement period
- Possible lack of storage space as system expands
- Possible lack of legal backing for system decisions.

If the Regulatory Branch does begin developing a full-scale expert system, the initial hurdle would be selecting regulations. A procedure for sifting through the Federal regulations would have to be developed to determine what can be input directly into the system and what can be excluded. This could create a problem in that vital information

[9]Edith Myers, "Not for Everyone; Expert System Technology is Recognized for Its Potential, but Realization Is Still a Ways Off," *Datamation*, May 15, 1986, p 28.

or regulations for a particular permit process might be left out. Many of the regulations are so complexly worded that it soon becomes unclear what material is substantial and what is not. This process of data manipulation will require a position within the Corps structure for an individual who would be in charge of perfecting the system. This individual would not need to be highly trained in computer technology, but would need to have a comprehensive understanding of the particular expert system being implemented. The individual would also need to be knowledgeable in the Corps' operations, permitting system, and legal requirements.

Updated regulations will prove a challenge to the data enhancement procedures. Every year numerous deletions and additions are made to the existing regulations. As soon as the expert system is created with the necessary regulations, a revised addition to these regulations may be produced. The challenge would then be how to change the system to include or extract the regulations in question. An expert system chosen on the basis of the four criteria outlined above would be able to accept new rules by simply entering them into the knowledge base. This would provide an advantage in this situation. However, the knowledge engineer may or may not be around to complete the necessary changes. Again, it is suggested that one individual or knowledge engineer be continually responsible for modifying and updating the system and making certain all agencies receive the necessary changes.

Because the regulatory program's data is so complex in its entirety, it will take a minimum of 1 year of testing before a completely bug-free system is online. Two stages of testing are common for expert system implementation. The first occurs in the research phase when the technical analysis and actual system operation are tested. In this phase, the researcher or knowledge engineer is responsible for ensuring the flow of accurate information within the system. In the second stage, actual field testing takes place in two phases. The first is a test by professionals in field situations to detect flaws in consulting sessions. The second is a test by actual field stations or users in the agencies throughout the Corps. These tests commonly uncover faults in the system that the knowledge engineer and the professional test failed to discover. If a problem does exist, the system is corrected and tested once again.

Depending on the system in use, this process of testing could take from 1 year to many, depending on how many researchers are testing and operating the system.

As the Corps system expands with more and more data, it may be necessary to expand the system. The capacity for expansion, however large, is limited in part by the shell itself and by the computer's memory. Most companies offering shells at the basic level also produce expansion shells which can readily be accessed from the basic shell. These advanced shells simply use the rules from the basic shell and embed them into their own structure, thus allowing the system to continue expanding without requiring a new shell to be programmed.

Until an active system is actually tested for the Regulatory Branch, it will not be known whether or not a decision made by the Regulatory Branch's expert system will be able to stand up in a legal situation or not. The legal aspect of expert systems in general needs additional research.

Methods of Evaluation

The initial step in the feasibility study was to become familiar with the latest technological advancements in the field of expert system development. Recent periodicals, texts, corporate brochures, professional papers, and actual system development manuals were reviewed.

The literature review highlighted the companies that were considered the leading authorities in the field of expert system development. From this, the field of company choices was narrowed down to four which offered comparable system shells with applications to this project.

By comparing information from the literature review and from individual companies with the requirements of the current project, the following criteria were developed for determining which expert system shell is most appropriate.

1. Memory or capacity of the shell. Due to the massive amount of text in the Federal regulations for processing permits, a system shell must have sufficient memory to store that information.

2. Experience of firm with expert systems. Corporations which have devoted extensive research and development efforts to providing a high quality, easy-to-prototype, and easy-to-use final product should be given preference.

3. Experience of firm in producing expert systems in the interest area of the Corps. Many corporations offer specialized products in particular fields or methods of application. For this reason, it was important to research corporations whose products are suited for this project.

4. Ease of use for the developer. Since many of the system engineers selected by the Corps may have little experience in expert system development and maintenance, the shell selected must be well documented and simple to use.

5. Ease of use for the end user. The shell must provide easy and user-friendly interaction with Corps personnel. Because the end users may have little or no computer experience, the chosen system must be simple and must be able to tutor the user as the user proceeds through a consultation session.

6. Training required to develop the system. Many corporations offer different system shells written in various languages. Depending on the language, different amounts of training are necessary to learn to develop an expert system. Such training ranges from classes to manual tutorials, depending on the corporation

7. Cost of the shell, production, and future distribution. Perhaps the most crucial element of system development is the cost. Again, systems vary in cost from extremely expensive to inexpensive; therfore, these costs must be considered as well as the ultimate cost of developing and distributing the system.

8. Capability to expand into more advanced systems. Because information will continually be added to the system, a system must have expansion capabilities.

Evaluation of Selected Shells

Once the selection criteria were established, they were used to analyze the shells offered by various firms. From this analysis, four shells were selected for closer examination: Human Edge's First Class, Software A&E's Knowledge Engineering System (KES), Texas Instrument's Personal Consultant Easy, and Goldhill's ACORN.

Each system was reviewed in depth. This review consisted of examining additional literature and individual corporate brochures and interviewing corporate representatives. With both Texas Instruments and Human Edge, demo disks were purchased and reviewed, and small systems were actually constructed on the disk.

After completing the review process of the four shells, the selection criteria were again used to narrow the choices to two final systems, Human Edge's First Class and Software A&E's KES. The reasons for this decision follow.

The final step was the evaluation of the two shells. Both are regarded as being suitable for the immediate project. Human Edge provided their demonstration diskette, which was reviewed and used to construct a small application system. On the other hand, Software A&E conducted a demonstration in order to provide an example of the operating procedures for KES.

ACORN (Goldhill Computers, Inc.)

This was the first system reviewed. Since it was programmed in LISP, it was the most complex to analyze. Prototyping a system on ACORN requires a hierarchical development process. The developer first needs to purchase the Golden Common LISP software, a tutorial of the LISP language, then purchase Golden Common LISP Developer software, a tutorial for developing LISP programs. And finally, to develop an expert system in ACORN, the LISP Development software, which is the actual shell, would be needed. In all, the developer would be required to purchase and be educated in the LISP language, its development processes, and its application to expert systems.

Despite this, ACORN is a comprehensive LISP programming environment available for personal computers. It has forward/backward chaining capabilities and takes full advantage of the speed and memory available on the PC. (See Appendix A for more features.)

Since Goldhill's development software is written in LISP, it was strongly suggested that LISP training be taken before trying to develop a prototype expert system. Whether that training was in the form of the various LISP tutorials or one of the classes offered by Goldhill, the added expenses could be well over $800* in addition to $5000 for the ACORN shell.[10]

ACORN was withdrawn from consideration because it was decided that LISP-based systems are less appropriate for the Corps' needs. Increasing efforts are being made by many corporations to use "C" as the primary language for expert system development. This language is proving to be more effective in the construction of expert sytems.

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*Due to rapid changes in the software market, prices quoted here should be verified through suppliers.

[10]"ACORN: An Expert System Building Tool from Goldhill" (Goldhill Computers, Inc., 1986).

Because of this, current PC applications for LISP systems are increasingly difficult to acquire.

Personal Consultant Easy (Texas Instruments)

This was the simplest version of an expert system development package offered. However, because of this simplicity, it was determined that the Corps' project was too complex and would ultimately be too large for the Texas Instrument (TI) system to handle.

Personal Consultant Easy is written in "C" and is a simple system to develop. The system is not as sophisticated as the others reviewed and therefore did not have as much versatility. The major drawback however, is its limited capacity of under 200 rules. Because of this limited capacity, Texas Instruments developed the Personal Consultant Plus, which is more advanced than the Easy.[11] The "Plus" only expressed 200 rules, which is still too few for the Corps' needs.

TI provided a demo disk, but when reviewed, it showed there were limitations, including limited development space and lack of versatility with various functions. Texas Instruments' products do, however, have backward and forward chaining capabilities and are very simple versions to use. The minimal expense of Personal Consultant Easy ($300) directly reflects the sophistication of the shell.[12] (See Appendix A for additional features.)

First Class (Human Edge)

This package proved to be the inexpensive alternative. Yet, because of this, it lacked many of KES's more sophisticated characteristics. First Class is a very developer friendly expert system shell. It is formatted specifically for the IBM personal computer, and has many specialty features, the most promising of which is its development in "C." This provides for simpler development efforts and application in conjunction with other programs such as Lotus 1-2-3 and other external programs.[13]

The most significant difference between First Class and KES is the former's development logic. First Class is example-based rather than rule-based, which means that the system is appropriate for situations in which data is in the form of typical examples or data samples (that might be kept in a data base or spreadsheet). For example, First Class uses a spreadsheet format to hold its data, and it can read data from other spreadsheets or data bases if desired.

Special features of First Class include a memo column which allows the developer to display text at the beginning of an advisory session. Many shells do not offer such textual input. In addition, text can be attached to specific examples and printed in an advice section to help explain why an answer was given. Finally, a complete tutorial with the shell package makes nonexpert prototyping of a system possible and affordable ($495 including shell, tutorial, and royalty rights).[14] First Class exhibits forward and backward chaining capabilities and can store over 200 rules at 200 lines per rule. Human Edge also provides copies of the finished system at no extra charge.

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[11] *Personal Consultant Series: Technical Report* (Texas Instruments, 1986).
[12] Paul Harmon, "Personal Consultant Easy," *Expert System Strategy*, November, 1986.
[13] *First Class Version 3.0* (Programs in Motion Inc., 1986).
[14] *First Class Version 3.0.*

Again, the limited rule capacity restricts the use of the shell. For $2500, however, a system developed on First Class can be upgraded onto Human Edge's Expert Edge Advanced, which is a more complex system that takes the rules formed in First Class and applies them directly to Expert Edge Advanced.[15] This allows expansion of an existing system and provides for increased data storage. However, no corporate training is provided for either First Class or Expert Edge Advanced. Therefore, it is left for the developer to interpret the tutorial manual. (See Appendix A for additional features.)

KES (Software A&E)

This was a far more sophisticated system, which has had extensive research and development efforts in the past year.[16] Because of this, KES is much simpler to develop than other standard expert systems written in "C." KES and has been designed for practicality, flexibility and usability. Unlike the other "C" systems reviewed, KES exhibits an 800-rule limit on the personal computer, which is adequate for the Corps' project.[17]

A unique feature of KES is that it is available as a rule-based production subsystem that uses deductive reasoning. Deductive reasoning is reasoning whose conclusions necessarily follow from the premises The knowledge in this subsystem is represented in the form of if-then rules. KES is also embeddable, which means that a KES-built expert systems can be embedded in other software, allowing knowledge-based components to be included in conventional applications.[18]

Similar to Human Edge, development options make KES very friendly for the final user. For example, user access to the built system is through windows, menus, and a simple dialogue. The developer adds this dialogue by inputting text into the system during development.

KES offers the following support features: (1) complete documentation of development procedures through the use of a comprehensive manual, (2) regularly scheduled training classes provided for a fee at corporate headquarters in Arlington, VA, and (3) a support service telephone number which can be used to contact KES technicians when questions arise regarding the development of the system. By using these services, the developer can access a variety of resources to help with any possible questions about development.

KES is available on a wide variety of computer systems including the IBM, Apollo, Sun, Tektronix, VAX, and CYBER. On the IBM and compatibles, however, KES runs on the standard DOS.[19]

Due to the more sophisticated system and the additional features, KES is priced at $4000, with a special price of $1000 for institutional use. It is delivered with a 1-year development and maintenance agreement which includes telephone consulting, debugging

[15] Mary Ann Koler, personal communication, Human Edge, Marketing Representative, February, 1987.
[16] Gary Zuckerman, personal communication, Software A&E, Marketing Representative, March, 1987.
[17] Zuckerman, personal communication.
[18] "KES for Today's Knowledge Based Systems," (Software A&E, 1986).
[19] Ricki Kleist, personal communication, Software A&E, Marketing Representative, March, 1987.

if necessary, and the delivery of all major revisions of the software and the documentation. Extended maintenance is available on a yearly basis at 10 percent of the current price.[20] Licensing KES systems requires the purchase from Software A&E of run-time versions of the developed system. Run-time versions for the PC are 90 percent of the original shell expense.[21] (See Appendix A for additional features.)

Detailed Examination of First Class and KES

The final analysis of First Class and KES consisted of reviewing a demonstration diskette from Human Edge and attending a Software A&E demonstration meeting.

The demonstration diskette purchased from Human Edge was very user friendly and provided relatively clear directions on how to operate a completed system. Developing a small system was somewhat more complicated, but with the help of the manual, a small prototype was constructed.

Although the small system did work, it did not provide enough information to give the researchers a definite feeling for the difficulty to be expected in developing a larger, more complicated system. Although the company was available for questions, they did not give satisfactory answers to specific questions comparing the proposed regulatory knowledge base to the demonstration system.

Overall, the demonstration disk proved that First Class works, and it gave over 20 small examples of actual systems. However, since the corporation did not provide additional information, the researchers were concerned about the availability of future support if the system was purchased.

The demonstration provided by Software A&E in Arlington, Virginia was far more comprehensive than the Human Edge demo disk. The system offered by A&E was much more refined, with a much higher degree of versatility. KES is continually under development, and upgrades are provided under the purchase agreement. Because of this, the Corps would receive the latest modifications in expert system technology. A&E support facilities seem to be more favorable than Human Edge's. The representatives were able to discuss, to a certain extent, the EPA's implementation of KES for a very similar project. This information provided assurance that KES can handle the present project and will have corporate support throughout its development.

After attending the meeting, it was obvious that the system offered by Software A&E was much more comprehensive and sophisticated than the others examined. Yet, its sophistication in no way hindered the ease of development or use. Because of the magnitude of the regulatory project, it was determined that KES was more capable of handling the data. Also, KES was recently used by the EPA to develop a water-related permit application system. The development of this system and its similarity to the present project provided added encouragement that KES could handle the requirements. It is therefore recommended that the Regulatory Branch use Software A&E's KES in developing a regulatory expert system.

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[20] "United States Price List" (Software A&E, 1987).

[21] Zuckerman, personal communication.

Summary of Evaluation

The matrix in Table 3 shows how the four systems stacked up against the eight evlauation criteria. KES (Software A&E) stands out in corporate support and relevant experience, and for those reasons it is recommended.

Table 3

Evaluation Matrix

Criteria	Goldhill	Texas Instruments	Human Edge	Software A&E
Memory Capacity	unlimited	<200 rule	>200 rule	800 rule
Firm's experience with expert systems	extensive	extensive	extensive	extensive
Firm's experience with E.S. relevant to the Corps' needs	marginal	minimal	marginal	maximum
Ease of use for developer	difficult	moderate	moderate	moderate
Ease of use for final user	moderate	simple	simple	simple
Cost of production	$5000	$350	$495-$2500	$1000 for institutions
Expansion capabilities	yes	yes	yes	yes
Corporate support and accessories	medium	low	low	high

Preliminary Development of a Prototype System

Given the above recommendation, the research team purchased KES from Software A&E. A prototype system is being prepared which is based on the EPA's guidelines (Section 404(b)(1), Water Pollution Control Act). This prototype is being developed as a demonstration of KES's capabilities and possibilities. Documentation of the prototype appears in Appendix B.

Based on the development which has taken place to date, it has become increasingly evident that KES, as cited in the recommendation, is a highly sophisticated system. As a result, it has been found that development of the prototype is a complicated and time-consuming process and one which is often overwhelming for a non-computer-oriented developer.

As development of the new system has progressed, it has become evident that the training course is a necessity, as Software A&E said would be the case. Because of the system's sophisticated capabilities, it requires the construction of many sections and subsections. Development of these sections, in turn, is complicated further by the necessity of understanding "KES grammar" (KES has developed its own system of grammatical commands). Each section, after being developed as an entity, must be tied together through a complicated series of commands and KES grammar for the prototype to operate correctly.

Despite these issues, the system development experience has been positive overall. By constructing the prototype, it has become clear that KES can easily accommodate the program required by the Regulatory Branch. The complex development procedures do cause more development problems, but the system's capabilities offset these. Because of its complexity, KES is an extremely versatile program that can store vast amounts of data, analyze the data in relation to end-user input, query other databases, and provide solutions to quite complicated problems.

4 VIDEO DATA STORAGE FEASIBILITY

Visual communications technologies--videotape, videodiscs, digital optical discs, and compact disc read only memory (CDROM)--are changing the use and design of business, institutional, and industrial management systems.[22] Research and development of videodisc systems began some 20 years ago and has expanded into a comprehensive network of optical storage systems which are beginning to have a major impact in the consumer video and audio playback market, the employee education and training field, the publishing industry, and the rapidly converging areas of office automation and data processing.[23] In keeping with this rapidly expanding technology, the researchers have investigated ways to incorporate videodisc or CDROM into the Corps' current regulatory program. This chapter takes an in-depth look into video technology and how it could best be used by the Corps to enhance the regulatory program.

Currently, videotape is the leading video medium for business, institutional and industrial use. This technology is based on the cassette tape concept. Information which has been magnetically coded and stored on videotape can be played back to the viewer on a screen by placing the tape in a video playback machine.

In many aspects, videodisc technology is more advanced than videotape. These 12-in. discs have information stored directly on the discs themselves. Videodiscs can store hundreds of times more information than videotape, and are far more sophisticated. They are read either mechanically with a stylus which reads grooves similar to those on a phonograph album or optically with laser light.

Digital optical disc technology is currently being used by very few corporations, since it is still in the early stages of development. It is a highly complex video system and one which is not relevant to the various regulatory program needs being reviewed in this report.

CDROM technology is the newest of the three technologies and is still being perfected. Compact discs are conceptually the same as videodiscs but are only 4-3/4 in. in diameter. This smaller size allows for less expensive production and a greater efficient disc storage space. Previously, the smaller size restricted what could be contained on a compact disc, but because of an advancement called compact disc interactive (CDI), it is possible to store video, audio, and textual information in digital form on the smaller compact discs. The discs are of much higher quality and durability than videodiscs, since they are produced and played back using laser light.

Entertainment applications first brought videodisc and compact disc technology to the attention of the general public. However, due to competition by the already established videotape entertainment trend and the fact that video and compact discs

[22] Rebecca Sturm, "High Tech Breakthrough: Interactive Videodisc," *Wilson Library Bulletin*, March 1985.

[23] Tony Hendley, *Videodiscs, Compact Discs and Digital Optical Disk Systems: An Introduction to the Technologies and the Systems and Their Potential for Information Storage, Retrieval, and Dissemination* (The National Center for Information, Media, and Technology [Cimtech], The Hatfield Polytechnic, Hatfield, U.K., 1985).

could not be reproduced in the home, the home video and compact disc market initially received poor public reviews and poor consumer demand.[24]

This misjudgment of the video market however, did not hamper the progress of video technology. From the advancements made by the home videodisc research came a new wave of video applications. The institutional and business sectors soon recognized the potential that the more advanced videodisc technology had over the videotape system. Businesses recognized the training and management potential of videodisc systems, thus beginning a new wave of research. From this research emerged a number of systems with capabilities far beyond those of videotape technology. The following sections will analyze, in greater detail, video and compact disc systems in production and how each could be used in the regulatory programs.

Videodiscs

In the fields of business, institutional, and industrial research oriented systems management, videodiscs are rapidly replacing video tape as primary tools for research, training, and documentation. From the point of view of the program producers, videodisc has a number of advantages over videotape.

Once a videodisc is mastered, replication costs are lower than for videotape. The transfer of programs from master videotape to row tape stock is an expensive, linear, sequential process. In comparison, videodiscs can be replicated quickly and inexpensively using a stamping process.

The large storage capacity of videodiscs is perhaps their most attractive feature. Discs formatted in accordance with the North American Television Standard contain either 108,000 frames or 1.6 gigabytes of available information storage per side.[25] This allows for 1 hour of playback per side or the storage of one-half million pages of text. This proves to be a tremendous advantage in data storage and retrieval. All data recorded on a 12-in. (305mm) videodisc or laser videodisc (LV) is indexed and can be called up by the user in a matter of seconds. Using conventional methods, such a process might take hours or even days of searching through paper documents or videotapes.

Videodiscs can carry both video and audio information, and several companies have developed techniques for recording very large quantities of graphic and textual data. This data may be combined with the audio and or video programming and the discs can be manufactured using regular videodisc production facilities.[26]

In addition to the above characteristics, videodisc systems exhibit the following features:[27]

- Slow motion.
- Fast motion.

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[24] Judy McQueen and Richard Boss, *Videodisc and Optical Digital Disk Technologies and Their Applications in Libraries, 1986 Update*, Library Technology Reports (The American Library Association, Chicago, 1986).

[25] McQueen and Boss.

[26] McQueen and Boss.

[27] McQueen and Boss.

- Freeze frame, which is a freeze on one among many frames of a motion sequence. Unlike videotapes, the frozen frame is a clear and detailed display.

- Still frame is an effect achieved through displaying a single frame designed especially for representing text or still photocopies without actually stopping the disk or "freezing" the frame.

- Scan allows the user to skip over several tracks at a time in either forward or reverse. This can be completed in seconds and is analogous to skimming through the pages of a book.

Two types of videodiscs currently exist on the market, capacitance videodiscs and optical videodiscs. Capacitance discs share conceptual similarities with the phonograph record. The most obvious similarity between the two is that they are played on equipment that uses a mechanical stylus-like device to read programming. The stylus reads two types of disc, grooved and ungrooved. To read grooved disc, the stylus physically rides in grooves on the disc. Because the stylus actually touches the surface, the disc must be kept clean. The grooveless capacitance disc has a distinct advantage over the grooved disc since the stylus movement is governed by a laser tracking device rather than by physically tracking a groove. Because of this, there is less wear on the disc and the stylus. The system also allows rapid random access of individual frames or sequences, whereas the grooved disc makes for a slower access time.[28]

Optical videodiscs use optical techniques rather than mechanical capacitance techniques for program recording and reading. Most commonly used are those optical videodiscs which use laser light for playback. The noncontact nature of the player and disc means that the discs will sustain less wear and provide a higher quality end product. Optical videodiscs are the newest technology and exhibit many advantages over the mechanical capacitance disc. First, because there are no physical grooves where dust and scratches can occur, the quality of output is much greater and the durability of the disc itself is much higher. The laser-read disc is coated with a plastic layer which protects the actual recording where the data is stored. Second, once the initial cost of the production facility is paid for, the cost of producing videodiscs with laser light is far less expensive than the mechanical capacitance method. And third, more information can be stored in laser-developed videodiscs because the laser can "burn" much smaller information codes into the disc than the mechanical method can.

The videodisc itself, however, is only a portion of a more complicated system of playback devices which produce the final output. Videodisc players are differentiated according to type as consumer, industrial, or institutional players. Such players are often described in terms of levels of sophistication and interactive operations which they support. Videodisc player systems can be divided into the following five levels (ranging in price from $500 for level 1 to $3500 for level 3 or 4):[29]

1. Consumer videodisc players offering basic serial playback features.

2. Consumer videodisc players offering serial playback plus still frame, forward and reverse play, and slow motion features controlled by a remote keypad.

[28] McQueen and Boss.
[29] Hendley.

3. Industrial players offering the same features as level 1 players but with their own internal microprocessor controller, providing them with processing power and internal memory.

4. Level 1 or 2 players interfaced to personal or business computers and fully controlled by them.

5. Very sophisticated multiple videodisc systems where two or more players are controlled by one external microcomputer and where the user can create graphics on the computer and overlay them on the video images, use still frame audio facilities, and merge in materials from two discs.

An increasing amount of research has been done in the field of linkages between videodiscs, videodisc players, and computer applications. "There is a considerable degree of variety in the interfaces designed to link level 1 and level 2 videodisc players with external computers."[30] And the level 3 videodisc players combine the interactive and immediate feedback capabilities of the computer with the audio and video programming recorded on the videodisc.

Interfacing can be accomplished in one of three ways:

1. Inserting controller cards in a slot in the computer.

2. Using diskette software

3. Using software stored on a chip soldered to the interface card.

This linkage between the computer and the videodisc player allows the program designer to develop interactive branching and sequencing instructions which would utilize the material on a disc in accordance with the reference used by a particular computer program or expert system program. Depending on the content and goal of the program, the videodisc player can be programmed to combine text and graphics from the computer with the audio and video material from the disc. Such capabilities provide an opportunity for dev[illegible] custom applications using commercially published discs as well as specially [illegible]tered discs.[31]

A majority of interfaces use disc players which have optical videodisc technologies.[32] Most popular players are the Pioneer consumer model VP-1000 and the Pioneer industrial player, the PR-7870.[33] Attention is increasingly being given to interfaces which support various types of computers. Currently, the IBM PC family is the focus of most interface development.

Many interfaces currently available are designed especially to enable a user to write sequencing instructions without previous knowledge of computer programming languages. Also, a wide variety of interface options are available, including ones that use a single screen and ones that constantly switching between the computer screen and the videodisc display monitor.

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[30] McQueen and Boss.
[31] McQueen and Boss.
[32] McQueen and Boss.
[33] McQueen and Boss.

Videodisc technology in business, institutional, and industrial settings is being established as a leading trend in training, sales, research, documentation, and data compilation. However, further research into the technology in recent years has led to the development of a new, more efficient and compact set of video systems--compact audio discs and CDROM.

Compact Audio Discs

Compact audio discs are used primarily for the reproduction of high quality sound. In the recording and playback process, the stylus does not touch the disc, thus causing no harmful wear. The playback system ensures nearly total accuracy in the decoded audio signal and the quality of sound reproduction is far better than any other audio reproduction system. However, because these discs are developed for audio production only, they do not meet most business, institutional, and industrial needs. Therefore, CDROM was developed to allow digital encoding with either video or audio input.

CDROM

Because it is designed to accommodate data in digital form, CDROM promises potential in the fields of data base publication and computer software distribution, as well as massive information storage capacities. Developments in the production of compact discs are progressing much more rapidly than did developments in videodiscs. Part of the reason for this is the fact that Philips and Sony Corporations agreed that 120 mm or 4-3/4 in. should be the standard for the physical format of the disc. This eliminated the time needed for a de facto standard to emerge through competition. These standardized discs have the capacity to store up to 600 megabytes, a quarter million pages of information, 1600 floppy disks of data, 34 hours of digitized audio data, or 5000 image frames.[34]

Again, data retrieval techniques are similar to those of the compact audio disc and optical videodisc. A laser read head captures and decodes the variations in "reflectivity" of the disc surface without making surface contact. This is the primary advantage, since durability is a necessity in a storage device with such high capacity. Retrieval speed ranges from 50 milliseconds (ms) to 1 second depending upon the video player.[35] CDROM players are more rugged and have different circuitry than compact audio discs. In mid-1985 most vendors showing CDROM drives had established prices of $1500 to $5000. By 1987 however, prices were quoted between $400 and $2290.

Like videodiscs, CDROM is available with interface capabilities to link computers and CDROM drives. Because of CDROM's limited performance characteristics such as slower retrieval rates, it is expected to be used primarily with microcomputers. Prospective buyers of CDROMs must be aware that "different CDROM publishers have developed different interfaces, and they usually offer these interfaces for only a limited range of player-computer configurations."[36] For example, Digital Equipment Corporation offers interfaces only between IBM PC and Philips' CDROM drives. Silver Platter offers interfaces between IBM PC and Hitachi or Sony drives. In the future,

[34] McQueen and Boss.
[35] McQueen and Boss.
[36] McQueen and Boss.

however, many feel that it will be possible to link any personal computer with any CDROM using an off-the-shelf interface which may cost $100 to $200.

CDROM has previously been at a disadvantage compared to videodiscs because it lacked the capacity to store and display video data. Recently, however, CDI has been developed which allows video cuts to be included in the mastering process. Also, within the next year, it will be possible to produce compact discs that can play audio sequentially with video and/or still frames, previously a feature only available on videodiscs. These improvements make compact discs more competitive with the videodisc systems discussed earlier.

Possible Applications of Video Technology in the Corps

Videodisc and CDROM are being used in many government offices, educational centers, corporate centers, and industrial settings worldwide. Uses extend from the operation of an American Airlines flight simulator and Ford mechanical training classes to the Royal Bank of Canada, which now uses CDROM as their primary economic information resource, rather than their previous high-priced, on-line computer service.[37] Similarly, the Corps could benefit from a wide variety of applications. This section discusses possible uses of video technology in three areas: education, data storage, and expert system interfacing.

Educational

Although the educational aspect of videodiscs and CDROM has a very broad application, the Corps' Regulatory I course, which is offered annually in various locations throughout the United States, will be used in this report to exemplify possible educational uses of videodiscs and CDROM.

The purpose of the Regulatory I course is to provide "a comprehensive background in the regulatory program and an understanding of current regulatory policies and procedures."[38] CDROM could enhance the Regulatory I course in two ways. First, CDROM interfaced could conceivably replace the current course, eliminating the high costs and organizational problems associated with a nation-wide course. Second, CDROM could enhance the existing course by supplementing its video capabilities in areas that require interpretations or definitions.

CDROM Course Replacing Regulatory I. Many Corps employees find it difficult to attend Regulatory I meetings because of space limitations and time conflicts. To resolve the problem, the entire Regulatory I course could feasibly be mastered onto a series of CDROMs, so that persons who could not attend the regularly scheduled class could order the disc and take the course at their leisure, conveniently remaining at their home office. With the use of the audio, video and textual capabilities of the videodisc and compact disc, each section of the course could be taught to individuals. Tests could even be given using the discs and computer interface capabilities.

Various methods could be used to portray the different sections of the course. For instance, since verbal communication is the most persuasive in any teaching environ-

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[37] Jeremy Main, "New Ways to Teach Workers What's New," *Fortune*, October 1, 1984.
[38] *Regulatory I Course Manual*, Proponent Sponsored Engineer Corps Training (PROSPECT), 1987.

ment, a majority of the course on the CDROM would be taught by a lecturer. But because CDROMs have the capability to record audio over text and video, the lecturer could be heard lecturing as the textual and video aspects provide a clearer definition of the points being taught.

As an example, sections of the course which cover the history, regulatory overviews, permitting processes, public notices, and jurisdictional compliance, could be lecture-taught with supporting graphics and textual information being portrayed on the screen. In this manner, the student can see practical applications and also listen to a professional speak on the subject. The Regulatory I manual would also be used and referred to in the course.

Other sections of the course, such as those describing special aquatic sites and construction methods could be highlighted by video images during the audio presentation. For example, the section called "Special Aquatic Sites" defines, describes, and delineates aquatic sites which are sensitive to human intervention. By using CDROM or videodisc, the lecturer could provide valuable information while the video identifies and gives examples of corresponding special aquatic sites. Similarly, types of construction methods for various projects could be portrayed on video and combined with the voice and graphic displays.

Designers of the video programs say they can reduce the time it takes to finish a course by 25 percent and increase the student's knowledge retention by 50 percent."[39] This is because the trainee remains involved in the classes by seeing, touching, and hearing things. The program keeps trainees alert by having them react to the lesson. Working in private, the student can stop and ask questions as he or she learns. By using CDROM or videodisc, the student is not left behind by a teacher who moves through subject matter too quickly or by a book that is too complex.

By interfacing the CDROM with a personal computer, the student can control the course at the desired level of learning. Such systems do much more than give a lesson. They let trainees move through the various subjects along their own paths, point out their errors, send them back to review material they have not grasped, let them skip material they already know, time them, and keep track of their progress.[40] This progress could then be reviewed by the Corps' regional officers if they felt it necessary. Also, by using CDROM, the courses could be taken at the student's convenience, creating a more efficient and productive atmosphere.

The outline of the course would be similar to the current one. The student would listen to one session, review important sections, and at the end be given a review period where the system asks questions. After completing the questions and reviewing problem areas, the student would have a choice of continuing to the next session or quitting until a later time.

As can be seen, there are many advantages to using the CDROM system, including:

- More efficient and timely training of new employees
- Graphics and video display

[39] Main.
[40] Main.

- Convenience for students
- Inexpensive training
- More efficient and productive use of professional time
- Greater opportunity for querying
- Appropriate pace for student's abilities
- More professional learning atmosphere
- Reusable disc (until course material changes).

Although there are many advantages, there are a few disadvantages which could cause major problems for implementing such a system for the Corps. First, not all agencies have computers, and many that do may find that their computer is not compatible with the particular CDROM player and interface that is purchased. Second, some feel that training through video lacks the needed attention-getting capability that the regularly scheduled classes offer. Third, many also feel that the lack of interaction and experience that Corps employees have with computer systems may detract from the efficiency of such an educational system. Fourth, mastering a course onto a disc could cost the Corps as much as $35,000 per disc. However, replication of discs after mastering is far cheaper ($10 to $20 per disc) than organizing the individual course meetings. Finally, updating of course discs could prove very costly and inefficient, depending on the amount and frequency of updating required.

Overall, however, the idea of a Regulatory I course on CDROM or videodisc is very promising. It would give agencies that otherwise could not send an employee to the scheduled class meetings an opportunity to teach regulatory procedures in the atmosphere of their home offices.

CDROM Supplementing Regulatory I. The second possible application for the Regulatory I course is as a partial supplement. In such a course, the students would be required to attend the scheduled course, which would be conducted by a professional, rather than taking the classes completely on the CDROM or videodisc.

The videodisc or CDROM, in this case, would act simply as a supplemental teaching aid. However, the format would be generally the same as if the complete session were on videodisc as previously described. The only differences would be that the lecturer would be present and that the student would not be able to choose his/her own pace.

The lecturer would have control over the video player and would activate it in areas where visual clarification of subject matter was necessary. Such areas might include graphic representation and video display of data involving, for example, a comparison of the characteristics of a particular project site and another site.

The advantages of such a supplemental system are simply the increased professionalism of the course and the detailed video description provided. Without it, the course would use slides, videotape, or overhead projectors to portray valuable information. With the use of CDROM and a personal computer, the professional could call up an actual permit application from a specific project to a large screen and go through the steps of completing the application and following the correct regulatory procedures. Such a method keeps the students alert by providing a secondary medium or attention

getter. The video aspect would keep the attention of the student while at the same time creating an interest in the completion of actual permit applications.

The primary disadvantage of such a system would be the increased cost of the course due to disc mastering expenses.

CDROM and videodisc technology can be applied to educational settings within the Corps' regulatory program. Although the previous descriptions dealt primarily with the Regulatory I course, it is clear that using CDROM in various Corps regulatory programs is very feasible and has several advantages over conventional educational practices.

Data Storage

The second possible use of videodisc or CDROM products within the Corps regulatory program is for storing and indexing documents, bibliographies, and reference data. The storage capacity of both videodiscs and CDROM make them prime mechanisms for storing the Corps' various data sources. The indexed retrieval capability of the discs also provide a means for quick access to and display of information. Such systems are termed "visual index systems."

There are numerous applications for such indexing systems within the Corps regulatory program. For example, one application might be to put all Federal regulations regarding Corps policies on CDROM. Using the indexing system, agency personnel could obtain valuable information in a matter of seconds, whereas using conventional methods of searching by hand could take many hours.

The ability to index the Federal regulations including the guidelines in the Federal Water Pollution Control Act, Section 404(b)(1) and all memorandums of understanding and memorandums of agreement, for example, would be a distinct advantage for those wishing to access various sections of each.

Reatco Inc. of Willowdale, Ontario produces a CDROM indexing system called "Findit." To use the system, the individual only needs to type in a few characters of the key word or phrase for the CDROM to establish the uniqueness of the word selected. If, for example, the individual typed "wet," the word to appear on the word list index might be "wetland." From that point, the individual would use the arrow key on the keyboard to choose the correct word or phrase which would key the CDROM to the exact portion of the disc that contains the desired information.

As another example, if the user wished to know the EPA's definition of "mud flats," he/she would type the word "mud." The computer would exhibit on the screen, a complete listing of indexed words containing mud. From the list, the user would direct the cursor to the words "mud flats defined" and press enter on the keyboard. The computer CDROM would immediately direct the computer to page 85352, section 230.42 of volume 40 Code of Federal Regulations (CFR) in the Federal Register.

The regulations, which are issued from OCE and consist of policy interpretations of key concepts and phrases, can also be indexed for rapid referencing on such a system. Similarly, a complete bibliographic listing of important books, periodical articles, or professional reports could easily be indexed by using a system similar to Findit. If, for instance, regulatory personnel needed information on dredge material in estuarine environments, they could enter any key word which would allow the CDROM index to begin the search. Possible terms which one could use to index might be "dredge," "estuarine," or the author's last name.

The use of such indexing systems in the daily operation of Corps offices would ensure a uniform understanding of government terms, regulations, and other references that are often too difficult to locate using conventional search methods. As a result, a more efficient, knowledgeable, and ultimately more professional regulatory program could result.

Several disadvantages of such a system include the following:

- Cost of initial setup and maintenance for the program could be high.
- Training is time-consuming and expensive.
- Lack of uniformity in the Corps equipment could result in development delays.

Expert System Support

Recently, many corporations which are developing expert system technology have introduced various shells which can be interfaced with other computer software programs. The research in this study is focused on interfacing videodisc technology with the KES expert system prototype discussed earlier.

In this setting, the video interface would be used primarily as a clarification tool which could be accessed through a single, predetermined command. For instance, if a particular question asked by the expert system was unclear to the end user, rather than randomly selecting an answer or having to stop and conduct research, the end user could type an "explain" command to access two methods of clarification for the question. First, the system would attempt to provide, in a textual format, an explanation of the question and the reason it was asked. Second, the expert system could interface with the video system, which would then display graphic or video features on the screen, giving the user a visual description of the subject matter contained in the question or some examples of possible answers to the question.

For instance, if wetland identification was a specific issue to be dealt with and a user was unsure about the identity of various wetlands, he/she could access the videodisc with an "explain" command and acquire a visual description of various classifications or identifications of wetlands. From these classifications portrayed on the video screen, the user could make a more definite identification of the wetlands being dealt with in that particular project.

In a similar situation, if the regulatory permit process contained a section regarding the classification of special aquatic sites which are described in 40 CFR, subsection E, (230.40-45), the user may wish to know more detailed information about the various classifications of special aquatic sites. By using an "explain" command, the user could activate the video system, thereby accessing a video description of all the necessary information describing special aquatic sites and the various classifications of these sites as described in the regulation. Following the brief video presentation, the expert system would continue with questioning at the point where the explanation was initiated.

The above examples are two in which the video description of the various components of the regulatory permiting process has an advantage over the textual description offered by an expert system. By seeing actual pictures of wetlands or special aquatic sites, the user would understand more clearly the environmental factors under consideration. With textual descriptions alone, the user might confuse or complicate the issue.

A video interface could conceivably be linked to all questions asked by the system which require a more in-depth explanation than that provided for by the system's textual attachment.

When investigating this joint technology for future use, it should be noted that many expert systems on the market do not have interfacing capabilities. KES, the expert system currently being used to develop a prototype program for the Regulatory Branch, contains interfacing capabilities which allow video interface for explanations and clarification upon the user's command.

Videodisc technology is a rapidly growing aspect of the computer era. As computers, and more specifically, expert system technologies, become commonplace in today's corporate setting, there is going to be an increasing demand for interactive systems. In its preliminary stage, videodisc technology promises an active future in the field of computer interaction.

5 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

A menu-driven electronic mail and bulletin board system has been set up for the Regulatory Branch of HQUSACE, Directorate of Civil Works. Using Dialcom computer service, branch employees can send notices within the branch and to other agencies that use Dialcom's electronic mail. Communication within the Regulatory Branch and among the agencies involved in the permit process has been greatly enhanced by this system. The Kbase bulletin board currently contains 17 categories in which users may ask and answer questions and pass on useful information. However, users must receive some training before they can efficiently use all services provided.

To find out if current software could accommodate the potentially large and involved expert system needed to support the Regulatory Branch, the researchers closely reviewed the expert system development software from four corporations. They found that the Knowledge Engineering System (KES) from Software A&E, Inc. adequately satisfied the evaluation criteria. In the process of developing a prototype system, however, it was found that the KES development process is less easy that anticipated. Training and support from Software A&E partially overcame this problem, and KES's definitely superior data storage and analysis power still make it attractive. Development of the prototype system has shown that such a system is feasible. Given the time and attention needed for full development, it could evolve into an integral part of the regulatory permitting process.

This report also reviewed video data storage technologies. Videodiscs (12-in. [305-mm] diameter) can store 108,000 frames or 1.6 gigabytes of data; disc players cost $500 to $3500. CDROM (discs 4-3/4-in. [120-mm] diameter) can store 5000 frames or 600 megabytes of data; players cost $400 to $2290. The primary advantage of these discs are long life (since the retrieval process does not involve physical contact with the surface) and extremely rapid data retrieval. When interfaced with a computer they can greatly enhance the possible applications of software.

Recommendations

Bulletin Board

To develop a successful bulletin board and provide for long term maintenance, these actions are recommended.

1. Include instructional materials for Dialcom and Kbase in the Regulatory Handbook.

2. Include an introductory session for Dialcom and Kbase in the classes provided for Regulatory personnel, particularly Regulatory I through IV.

3. Prepare instructional materials and make workshops available to district offices. The system manager could be responsible for preparing the materials and for conducting the workshops for 1 year. Other arrangements, if necessary, could be made after that time.

4. As a means of increasing the regulators' awareness of the capabilities of Dialcom and Kbase, the system manager could prepare a newsletter and distribute it

through conventional mail. A larger percentage of office personnel would potentially have access to such a newsletter.

5. A program of regional system coordinators could be established. The coordinators could be given the responsibility of encouraging use of Dialcom and Kbase, as well as being primary contributors to the bulletin board.

6. For long term operation and maintenance, a system manager must be assigned who will access the system daily, respond to any messages, promote use of the system, and resolve problems as they arise. These responsibilities would not necessarily require full-time attention, but they also cannot be merely an incidental part of the job description. To be successful, the system requires an attentive manager.

Expert System

Based on the evaluation summarized in Table 3, the KES software from Software A&E, Inc. is recommended. Developing an expert system for the Regulatory Branch requires a system to have the capacity to retain the accumulation of regulatory information. Expectations for the system stem from the goal of the project, which is to incorporate the Corps' permit application process into expert system technology. Software A&E's KES can best attain this goal. KES is supported by a full technical staff on duty to aid with problems in development. The cost of the system is justified by its highly advanced technical utilities and comprehensive support services.

However, based on the experience acquired through this initial development, four additional measures will be needed to develop a fully operational expert system.

1. To gain a useful understanding of the regulatory process, a comprehensive flow chart should be developed which exhibits all the components involved in the permitting process (Rivers and Harbors Act, and Section 404 of the Federal Water Pollution Control Act of 1972). This would require research and interviews of all district and division chiefs and HQUSACE personnel. In addition, the similarities and differences in the permitting processes of each office must also be evaluated. This information would aid in the creation of a flow chart which would then be incorporated into the expert system.

2. Throughout the duration of the development process, the Regulatory Branch's attorney should periodically review the system to insure its legality.

3. Before the full scale system can be developed, a computer programmer or individual with expert system experience should be hired to carry out the tasks of development.

4. After final development and operational testing are complete, the Corps' attorney will need to review the system again to insure its legal stability and to determine its legal reinforcement in case of litigation.

Video Data Storage

Videodisc or CDROM technology could be used to support the Corps' regulatory program in three ways.

1. They could either supplement or replace the Regulatory I class.

2. Pertinent regulations could be stored and indexed on a disc, making it faster and easier to use them. They would be available in seconds at the keyboard instead of hours in library.

3. They could support an expert system by providing pictures and examples to support the system's explanations and conclusions.

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APPENDIX A:

CHARACTERISTICS OF EXPERT SYSTEM SHELLS FROM FOUR COPORATIONS

Corporation: Human Edge Software, Palo Alto, CA

Expert System Software

1. First Class
2. Expert Edge Advanced
3. Expert Edge Professional

*Description: First Class Version 3.0**

- Replaces Expert Ease as a much more efficient and user friendly expert system shell.
- Formatted for use on IBM personal computers.
- Example-based rather than rule-based, which means that the system is good for situations in which data is in the form of typical examples or data samples (that might be kept in a data base or spreadsheet). For example, First Class uses a spreadsheet format to hold its data, and it can read data from other spreadsheets or data bases if you wish. Most rule-based systems are slow, difficult to debug, and have less than optimal user interfaces. First Class' example-based format solves these issues and makes for easy nonexpert prototyping.
- Written in "C" Language for easy development and application in conjunction with other programs such as Pascal and FORTRAN.
- 200 lines per rule capacity (unlimited number of rules).
- Unlimited, royalty-free distribution, meaning the expert system developed can be commercially marketed.
- Forward/backward chaining
- Rules developed in First Class can simply be transferred onto Expert Edge Advanced when a more advanced system is needed.
- $495 including shell, tutorial, and royalty rights.
- A memo column allows the developer to display text at the beginning of an advisor session. Many shells do not have this feature.
- Text can be attached to specific examples and printed in the advice to help explain why an answer was given.

*Information in these lists is taken from brochures about the products.

- A new automatic report generator can produce, on disk, a running log of the session, or of many sessions.
- The run-time program is standard with all new copies of First Class.
- Over two dozen sample knowledge bases, some from actual customers of Human Edge, help the developers learn advanced features and give them ideas for applications.
- A complete tutorial provided with the shell package makes nonexpert prototyping of expert system possible and affordable.
- A General Foods sample division representative created an expert system in two days which is now in daily operation for General Foods.

Description: Expert Edge Advanced

- Rule-based programming; accepts rules from First Class system.
- Much faster and more powerful than First Class.
- Backward and forward chaining capabilities (probabilities and certainties)
- $2500 including shell, tutorial, and royalty rights.

Description: Expert Professional

- This is a "super-techie's tool," which means this system is usually only used by high tech industries and in specialized professions such as medicine.
- Contains interactive videodisc interface.
- Usually used only for diagnostic-type systems.
- $5000 including shell, tutorial, and interactive videodisc interface.

Comments:

Any of the three systems could support the proposed project. First Class has ample rule development space to complete a large initial system. However, Advanced would be needed to complete a system which includes all regulations. The fact that all three are written in "C" is a plus, since beginners would find it easier to develop a system.

Corporation: Goldhill Computers, Inc., Cambridge, MA

Expert System Software

1. Golden Common LISP
2. Golden Common LISP Developer

3. Golden Common LISP Run (run-time versions)

4. Goldworks

Description: Golden Common LISP

- Tutorial for the LISP language
- Necessary for learning to develop expert systems which use LISP
- $350

Description: Golden Common LISP 286 Developer

- Tutorial for developing LISP programs (not expert systems, just programs)
- $400

Description: Golden Common LISP Run

- Delivers run-time versions of already-developed expert system to various agencies without them actually having to develop a system from their own shell. (Allows the prototyper to make copies of the developed expert system and distribute it.)

Description: Goldworks (ACORN)

- Based on Golden Common LISP family of products previously described.
- Contains the expert system development software.
- Considered most comprehensive LISP programming environment available for PCs.
- Forward/backward chaining
- Large rule capabilities. Takes full advantage of the speed and memory available on the Intel 80286 microprocessor (up to 15 MB) and 80386 (up to 24 MB) over expert systems developed within the 640K limitation imposed by MS and PC-DOS.

Comments

Since Goldworks development software is written in LISP, it is strongly suggested that some type of LISP training be taken before trying to develop a prototype expert system using it. Whether that training is in the form of the LISP tutorial or one of the classes offered by Goldhill, the added expense can be substantial. The advantages that an expert system written in LISP has over those written in "C" are not substantial enough to justify the added expenses. However, if the individual developing the expert system already has a LISP background, the added power of the LISP-based expert system could prove to be helpful in the long run.

Corporation: Software Architecture and Engineering (A&E), Inc., Arlington, VA

Expert System Software

Knowledge Engineering System (KES)

Description: KES

- More sophisticated but easier to develop than a standard expert system that is written in "C".
- Very practical, flexible, and usable.
- No limit on rules on mainframe system.
- 800-rule limit on PC applications. This is adequate for the regulatory project.
- Production system (if then).
- Hypothesis and testing.
- Makes inferences based on Bayesian theorem.
- System is embeddable, which means that KES-built expert system can be embedded in other software, which allows knowledge based-components to be included in conventional applications.
- User accesses a built system through windows and menus or a simple dialogue. This makes a final system very user friendly.
- Complete support and training through documentation, regularly scheduled training classes, and contracted consultants.
- Available on numerous computers including IBM PC, Apollo, Sun, Tektronix, VAX, and CYBER.
- Major discounts for run-time systems make distribution practical.
- IBM PC and compatibles run on DOS operating system and cost $4000 plus $1200 for training. However, academic institutions receive a 75 percent discount on systems to be used for instruction or university funded research.
- Corporation offers a 30-day test period.
- KES is delivered with a 1-year maintenance agreement which includes telephone consulting, debugging (if necessary) and the delivery of all major revisions of the software and the documentation. Extended maintenance is available on a yearly basis at 10 percent of the current price.

Comments

The EPA has recently finished developing an expert system for water permit approvals. They will soon make that system available to anyone who wants to use it.

Corporation: Texas Instruments, Inc.

Expert System Software

1. Personal Consultant Easy
2. Personal Consultant Plus

Description: Personal Consultant Easy

- Very simplistic.
- Easy to develop.
- Not as sophisticated, therefore, does not have as much versatility as the other systems reviewed.
- $300 including tutorial.
- Demonstration diskette is helpful; shows that any person can develop a small expert system without extensive training.
- Minimal rule capabilities.

Description: Personal Consultant Plus

- More advanced than "Easy."
- Has a 200-rule limit which makes it nearly useless for developing a large project.
- Allows greater flexibility in allowing the developer to customize the application than "Easy" does.

Comments

Although the demo disk proved that expert systems can be developed by a noncomputer-scientist, the limitation of rule development space makes this expert system a little too simple.

APPENDIX B:

USER DOCUMENTATION, EXPERT SYSTEM PROTOTYPE, "SYSTEM 1"

This prototype system, built on KES,* is a simplified demonstration of how an expert system decision making package could be developed for the Corps of Engineers' Section 404 permitting process. The questions developed in the prototype are not intended to be complete; rather, they are merely an example of the capabilities of KES.

Hardware Requirements

System 1 requires an IBM AT or compatible with DOS level 2.0 or higher with 500K bytes of available memory.

Installation Procedure**

1. Access the DOS prompt and insert the diskette labeled Disk 1 in the a: drive on the PC.

2. Change the default drive to the one containing disk 1; type **a:**

3. Type **install** and press Return. A brief welcome statement appears with the following prompt:

   "Please enter the name of the current disk drive? A"

4. Press Return to accept the default drive "A". The following message appears on the screen:

   "Please enter the name of the hard disk for kes2.3? C"

5. Press Return to accept the default name "C", or Enter for another name. The following message appears on the screen:

   "Is the KES2.3 path already created (Y/N) N"

6. Press Return to accept the default response "N" for no. The following message appears on the screen:

   "Please enter the new KES2.3's path name? \kes2.3"

7. Press Return to accept the default path name "kes2.3". The following message appears on the screen:

---

*Knowledge Engineering System (KES), from Software A&E, is a software tool used to develop, implement and support expert systems.

Text in **bold face type (other than headings) is what you type in to use the command. Text enclosed by < > is general and must be replaced by specific text (a filename or a number) in an actual command.

"Please make sure that you are ready to copy files! Enter any key when ready"

8. Press Return to proceed. After a series of file names is displayed on the screen, the following message appears:

   "Do you have more diskettes to do (Y/N) Y"

9. Press Return to accept default "Y". The following message appears:

   "Please insert the next diskette and hit <return> when ready."

10. Insert the diskette labeled disk 2 and press return. After a series of file names is displayed on the screen, the following message appears:

    "Do you have more diskettes to do (Y/N) Y."

11. Repeat steps 9 and 10 for disks 3 and 4. After disk 4 is copied, the following message appears:

    "Do you have more diskettes to do (Y/N) Y"

12. ***Type "N" for no and hit Return to continue. The following message appears on the screen:

    "Do you want to set up batch commands for embedded KES (Y/N) Y."

13. ***Type "N" for no and press Return to conclude installation procedures. The following message appears.

    "Thank you! Enjoy working with your KES2.3!"

Accessing the Prototype

To access and run the prototype, return to the MS-DOS prompt.

1. At the prompt, type **CD \KES2.3PS.** A typical prompt customization will display the following on the screen:

   C:\KES2.3PS>

2. At the prompt, type **KESR System1.pkb.** The following messages appear on the screen:

   "Knowledge Engineering System (KES), Release 2.3 Copywrite (C) 1986, Software Architecture and Engineering, Inc."

   "Loading the Knowledge base "system1.pkb"."

   "Welcome to the 404 (b)(1) Permitting system"

You are now ready to run a consulting session with the system. After reading the introductory statement you may proceed with the consultation.

The Question Process

The questioning process is self-explanatory. Each question is followed by a list of possible answers. Choose the answer which best describes your situation by either typing the number of the desired answer or typing the answer itself and hitting Return.

After answering a question, the computer automatically proceeds to a follow-up question, the contents of which depend on the answer to the previous question.

The computer will lead you through the questioning process until it has enough information to determine its final suggestion.

Since the particular permitting process is composed of various steps, the system will conclude a section with a banner which displays an intermediate step's recommendation. In many cases, this intermediate recommendation will be highlighted by a double banner, for example:

```
*****************************************
        No Section 404 Permit is required.
*****************************************
```

and be followed by an additional series of questions that must be answered in order for the system to make a final recommendation.

If the computer asks a question which is unclear or needs to be clarified, type **explain** at the question prompt. This will be followed by a full explanation of what the question is asking and some possible results due to various responses. Once the explanation is concluded, the computer will ask you to "return to continue". Often times Return must be hit more than once in order to return to the questioning sequence. The questions will resume at the point where you left off.

Possible End Decisions

This particular permitting prototype has a variety of concluding suggestions. See Figure B1 for a decision chart showing what conditions produce what suggestions.

Questions Included in Consultation

1. How many acres are involved in the Project?

2. Is the proposed activity located within the waters of the United States of America?

3. Is the proposed activity a normal farming, silviculture, and ranching activity, such as plowing, seeding, cultivation, minor drainage, and harvesting for the production of food?

4. Does the proposed activity involve excavation, dredging, and/or disposal in navigable waters of the United States?

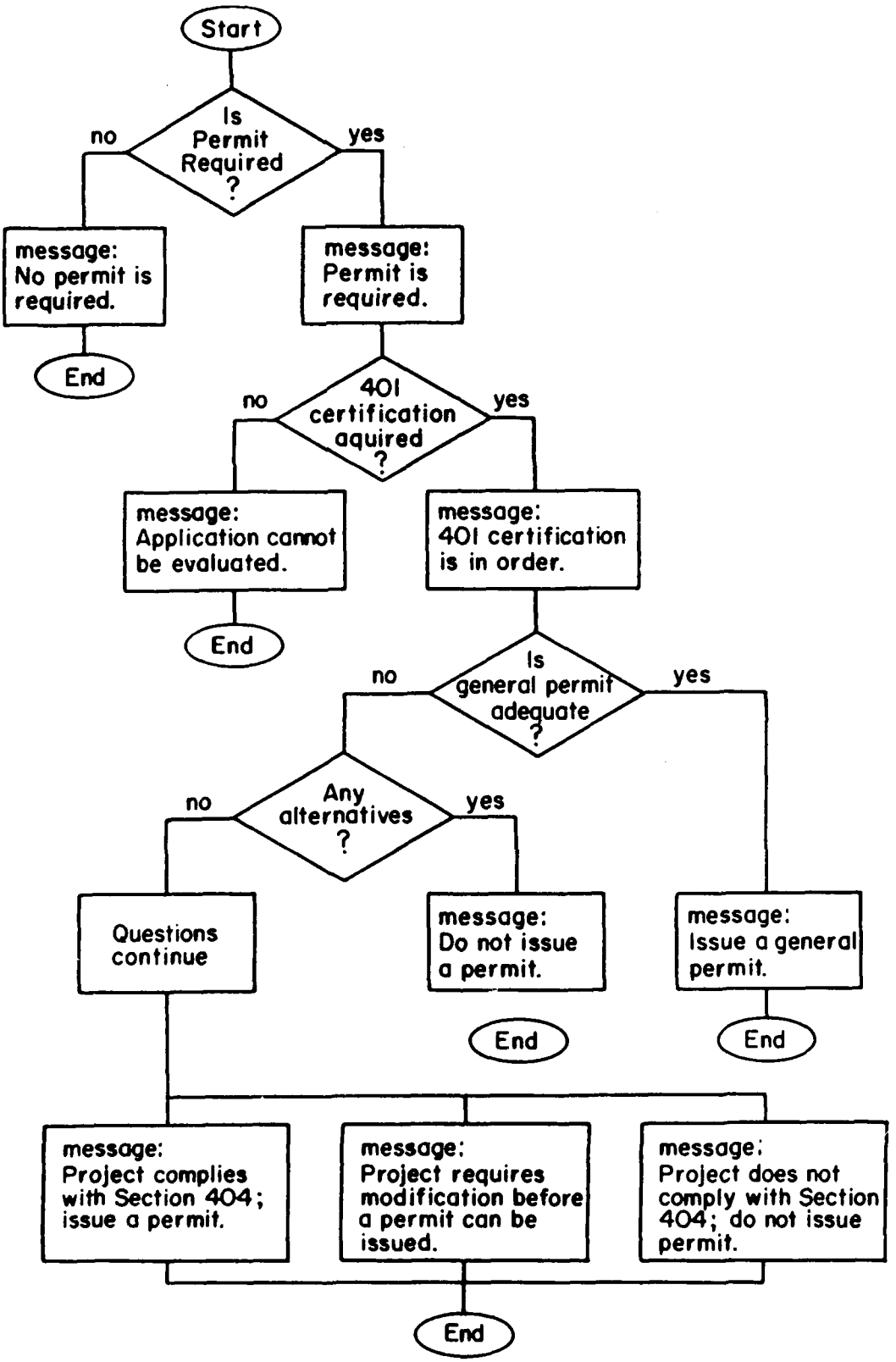

Figure B1. Conditions producing concluding suggestions in System1.

5. Does the proposed activity involve the discharge of dredged or fill material into waters of the United States?

6. Has the applicant received certification under Section 404 of the Federal Water Pollution Control Act?

7. Are these activities similar in nature and impact upon water quality and the aquatic environment?

8. Will the activities have only minimal adverse effects when performed separately?

9. Will the activities have only minimal cumulative adverse effects on water quality and the aquatic environment?

10. Is there a practicable alternative to the proposed discharge, such as not discharging into the waters of the United States or discharging into an alternative aquatic site with potentially less damaging consequences?

11. Will the discharge of dredged or fill material change the velocity of the body of water?

12. What is the anticipated change in velocity?

13. Will the discharge result in a significant change in the elevation or contour of the substrate?

14. Will the discharge alter the chemical characteristics of the water body?

15. Have appropriate and practicable steps been taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem?

Recommendation Scenarios

Because the task of including all possible recommendation scenarios within the system was too extensive for the development time, only a fraction of the final recommendations were programmed into the system. Therefore, the system will often conclude the consulting session with an "unknown" statement. This simply means that the recommendation corresponding to your input was not entered into the program. It is important to note, however, that in a full scale system, all recommendations would be programmed into the system.

For the convenience of running a consultation without reaching an "unknown" conclusion, the following list of scenarios has been prepared which, if followed, will result in a final recommendation.

All scenarios will begin at the question regarding practicable alternatives and continue to the final recommendation.

Compliance

Scenarios which would result in the project being in compliance with Section 404(b)(1) of the Federal Water Pollution Control Act:

	Scenario 1	Scenario 2	Scenario 3
1. Practicable alternative	no	no	no
2. Velocity change	no	no	no
3. Elevation change	no	no	yes
4. Chemical alteration	no	yes	no
5. Appropriate steps taken	yes	yes	yes

Modification

Scenarios which would result in the project requiring modification measures before it complies with Section 404(b)(1):

	Scenario 1	Scenario 2
1. Practicable alternative	no	no
2. Velocity change	yes	no
3. 1 ft/sec increase	yes	n/a
or		
4. 0.1 ft/sec decrease	yes	n/a
5. Elevation change	no	yes
6. Chemical alteration	no	yes
7. Appropriate steps taken	yes	yes

Noncompliance

Scenarios which would result in the project not being in compliance with Section 404(b)(1) Guidelines.

	Scenario				
	1	2	3	4	5
1. Practicable alternative	no	no	no	no	no
2. Velocity change	yes	no	yes	yes	yes
3. 3 ft/sec increase	yes	n/a	yes	yes	yes
or					
4. 1 ft/sec decrease	yes	n/a	yes	yes	yes
5. Elevation change	yes	yes	no	yes	no
6. Chemical alteration	yes	yes	no	no	yes
7. Appropriate steps taken	no	no	no	no	no

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